CANADA

DEPARTMENT OF ENERGY, MINES AND RESOURCES

MINES BRANCH

OTTAWA

FUELS RESEARCH CENTRE

DIVISIONAL REPORT FRC 67/104-

TRENDS IN PER CAPITA CONSUMPTION OF ENERGY IN CANADA

by

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September 1967

90-04546/

The consumption of energy is more and more generally considered as a valuable index of industrial activity. Because of the large annual relative increase of population in Canada, it is the energy consumption per capita, which can give a more accurate representation of the progress made by the average Canadian rather than Canada as a nation. It is also interesting, for future research work in the field of energy technology, to study the trends in utilization of the various energy sources in Canada, and also to examine the regional differences that occur in this vast and diversified country.

The trends in the consumption of electricity per capita, in Canada and in each province, during the last three decades, will be considered in the first part of this paper, together with the variations in the real gross national product per capita. This analysis will be followed by a study of the trends in the per capita consumption of energy obtained from the main sources in Canada since 1950.

TRENDS IN THE INDIVIDUAL CONSUMPTION OF ELECTRICITY IN THE CANADIAN PROVINCES

Figure 1 shows the estimated variations of the generation and consumption of electricity, and also the trends of the Gross National Product (G.N.P.) in Canada from 1935 to 1965. The G.N.P. is given in fixed Canadian dollars of 1949 to correct for inflationary tendencies. While the real G.N.P. has increased fairly regularly about four times between 1935 and 1965, the generation and the almost equal consumption of electricity have increased about seven times during the same period, but at a much faster rate of increase since 1950.

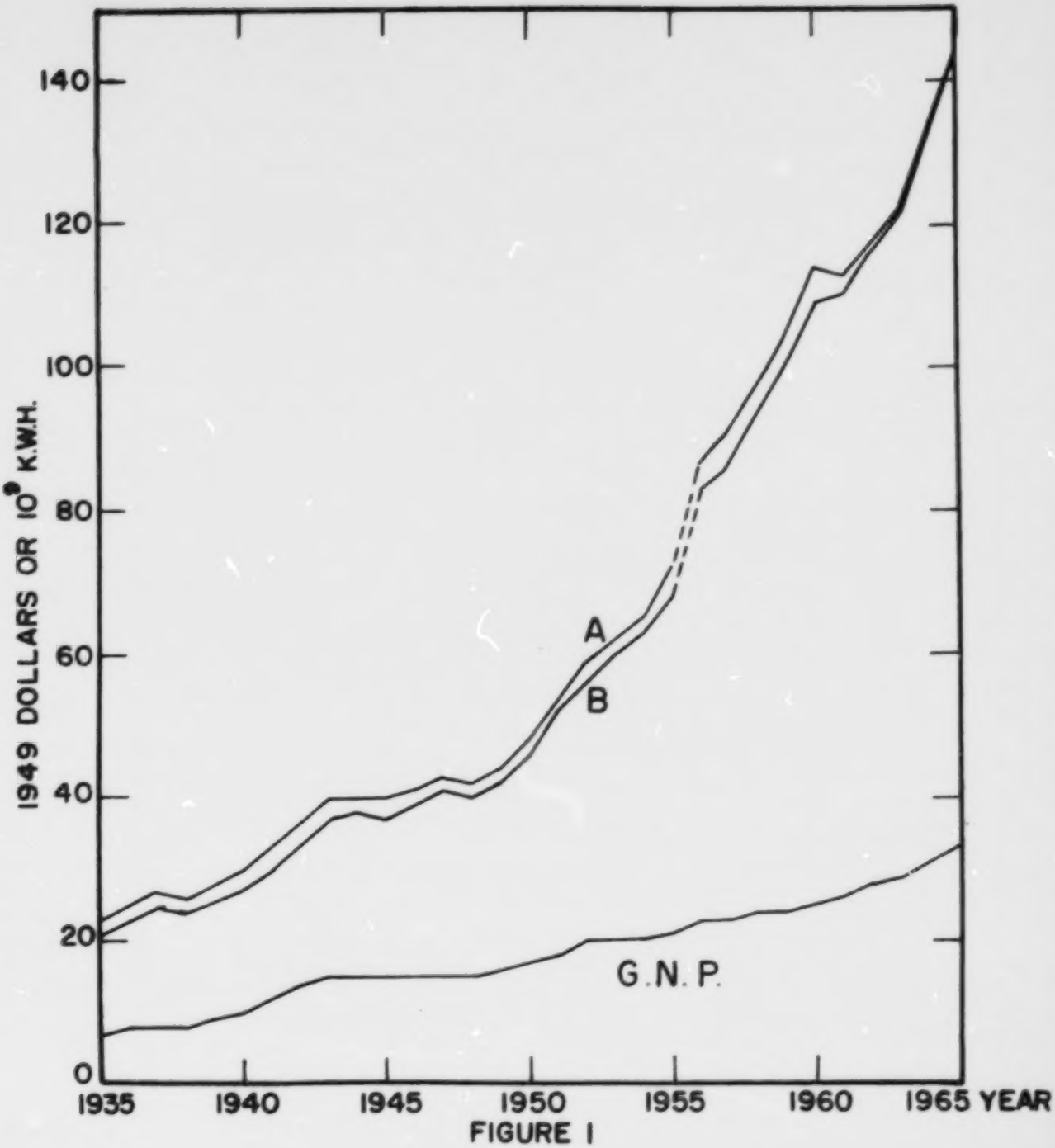


FIGURE 1

GNP - Gross National Product in Canada, in Canadian dollars of 1949.

A - Electricity generation in Canada, including industrial establishments after 1956, in kwh.

B - Electricity consumption in Canada, including industrial establishments after 1956, in kwh.

Source: Dominion Bureau of Statistics (D.B.S.)

However, as the population of Canada has greatly increased in the last three decades, and at changing rates, it is more significant to consider the same data on a per capita basis for each year, as shown in Figure 2. Whereas the real G.N.P. per capita has - not so regularly - increased about 2.5 times over the same period, the generation and consumption of electricity per capita have increased 3.5 to 4 times, but at a more regular rate of increase than the total data of Figure 1.

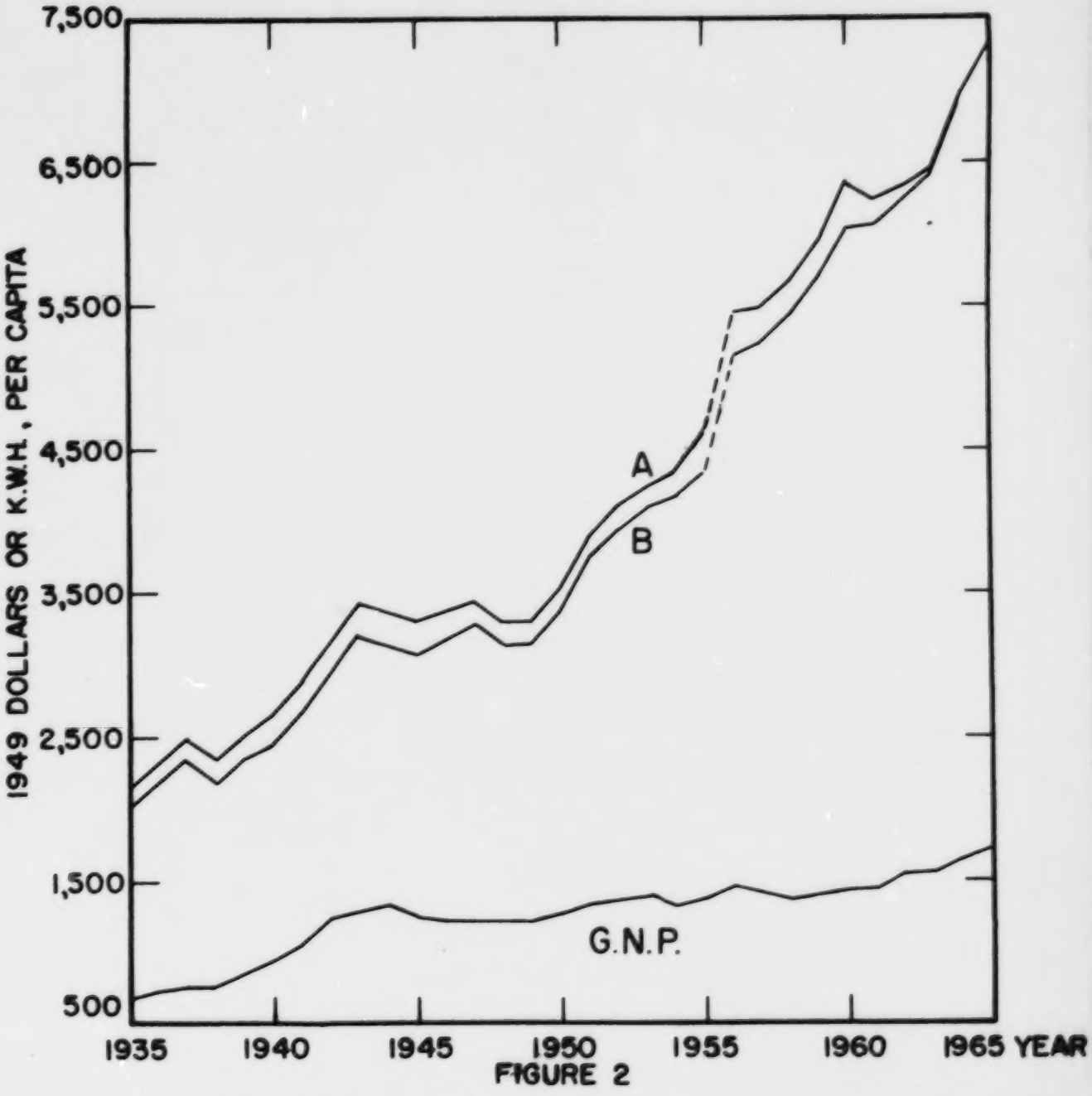


FIGURE 2

GNP - Per capita Gross National Product, in Canada.
A - Per capita electricity generation, in Canada, including industrial establishments after 1956.
B - Per capita electricity consumption, in Canada, including industrial establishments after 1956.

Source: D.B.S.

As economic conditions vary considerably from one region of Canada to another, it is more revealing to consider the trends in the consumption of electricity per capita in the various provinces, as shown in Figure 3 for New Brunswick, Nova Scotia and Prince Edward Island. The data for the first two Maritime provinces are about half of the national averages. The figures are even considerably lower for the small P.E.I. rural area. In all three cases the rate of progress, although improving, is still below the national average. New Brunswick has shown the best improvements in the last decade.

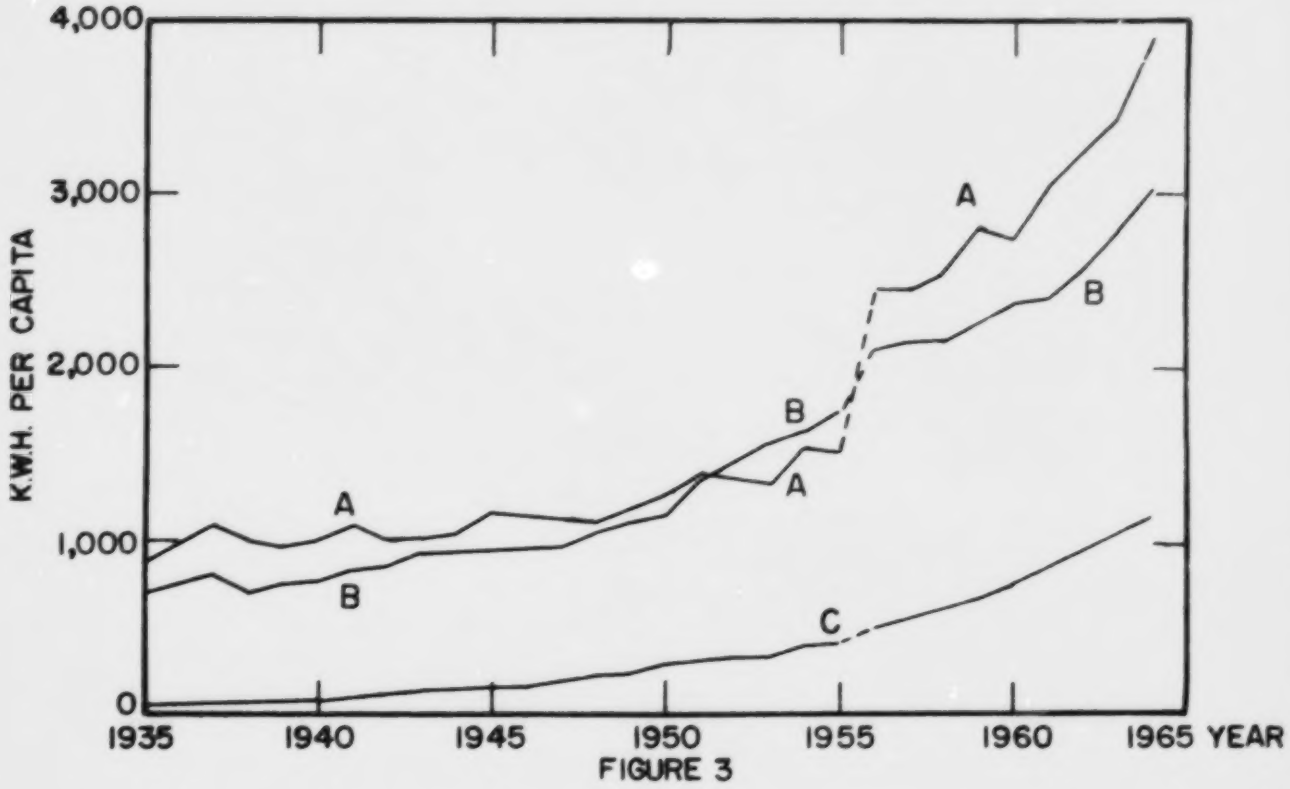


FIGURE 3

Electricity consumption per capita, including industrial establishments after 1956.

A. New Brunswick
B. Nova Scotia
C. Prince Edward Island.

Source: D.B.S.

The trends in both generation and consumption of electricity per capita in the most populated provinces, Ontario and Quebec, are given in Figure 4. Whereas Ontario has generally been close to the national averages, the Quebec data are far above - in fact the highest in Canada - with notable exports to other provinces, including Ontario, where the consumption usually exceeds the generation of electricity, and the remaining undeveloped hydro-electric sites are now scarce and less attractive than those in Quebec, because of their limited potentials and relative distances to industrial areas of high energy consumption.

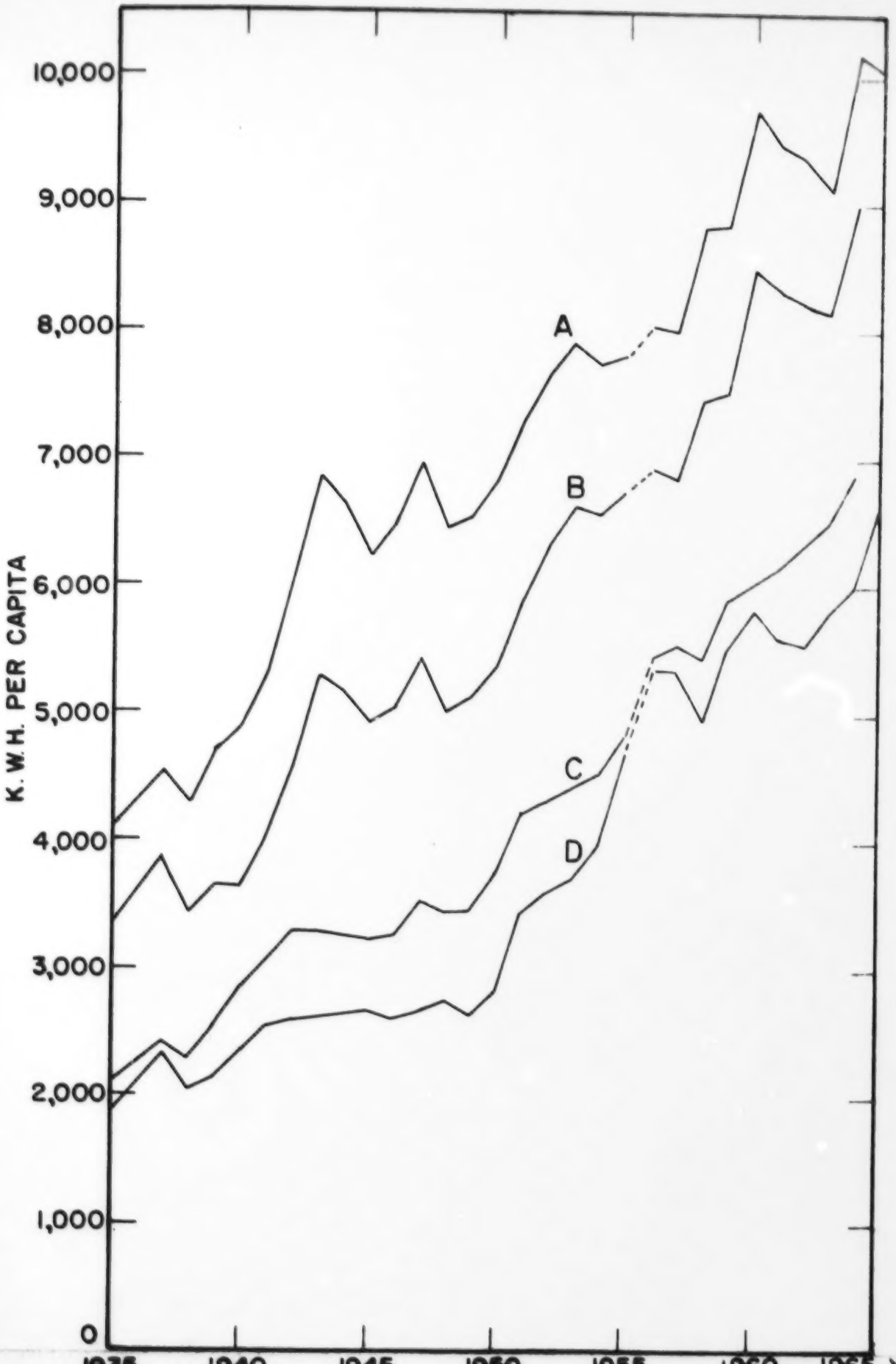


FIGURE 4

Electricity per capita, including industrial establishments after 1956.

A. Quebec generation.
B. Quebec consumption.
C. Ontario consumption.
D. Ontario generation.

Source: D.B.S.

Figure 5 shows the variations in consumption of electricity per capita in the Prairie provinces. Manitoba has the best record, close to the national averages, thanks to its long established manufacturing industries. Alberta and Saskatchewan had very low consumptions before World War II, but are now catching up because of their growing mineral industries (petroleum in Alberta, potash in Saskatchewan), with New Brunswick and Nova Scotia, at levels about half of the national averages.

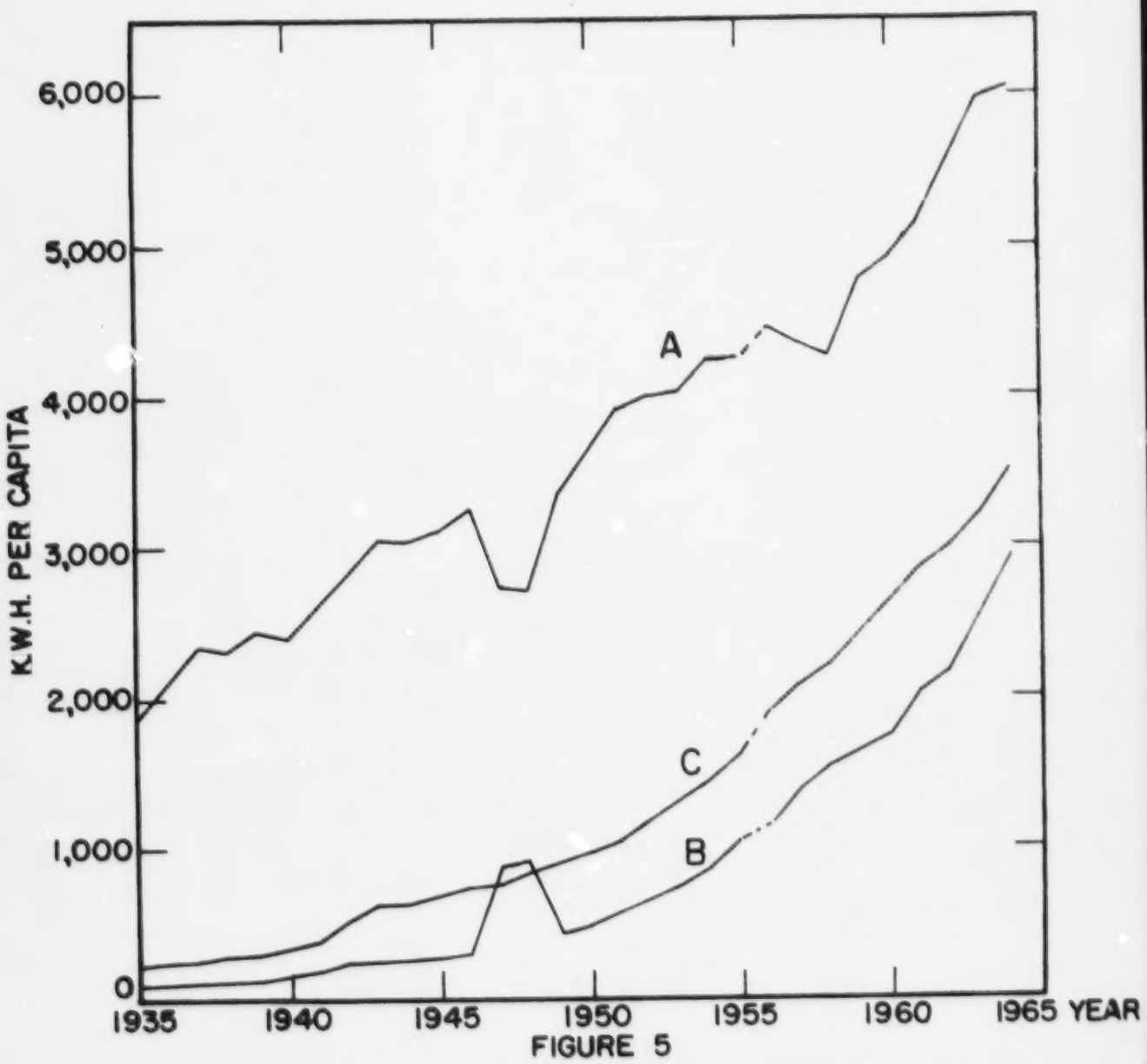
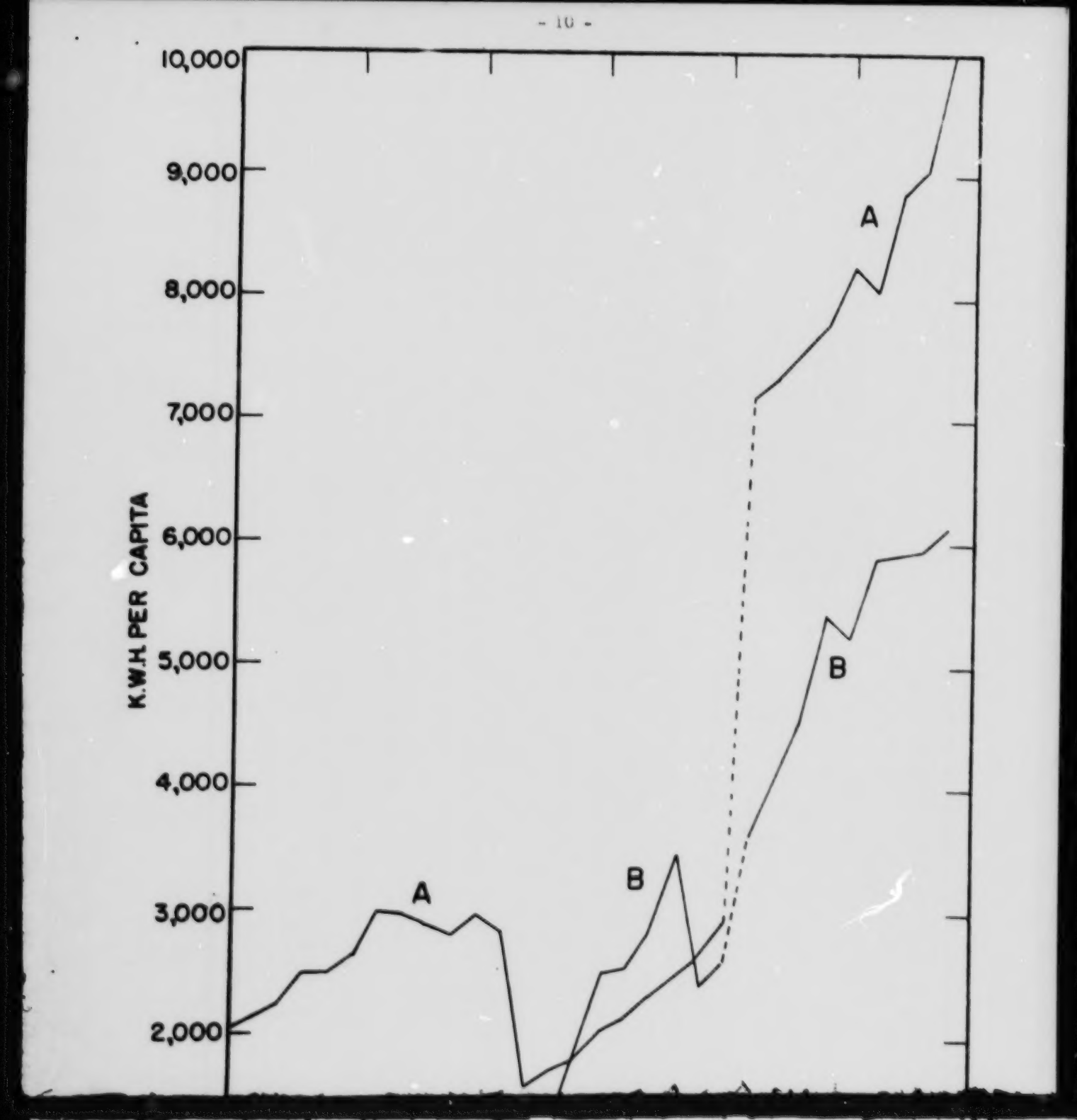


FIGURE 5

Electricity consumption per capita, including industrial establishments after 1956.

A. Manitoba.
B. Saskatchewan.
C. Alberta.
Source: D.B.S.

Similar data for British Columbia and Yukon from 1935 to 1947, and separately for British Columbia and for the Yukon and Northwest Territories since 1948, are given in Figure 6, showing much larger increases for B.C. between 1955 and 1956 than for the other provinces. These increases were partially caused by a change in the D.B.S. statistical records in 1956, when the data for industrial establishments were included with the central electric stations. B.C. is already reaching the highest electricity consumption per capita of all the provinces and has the largest rate of increase.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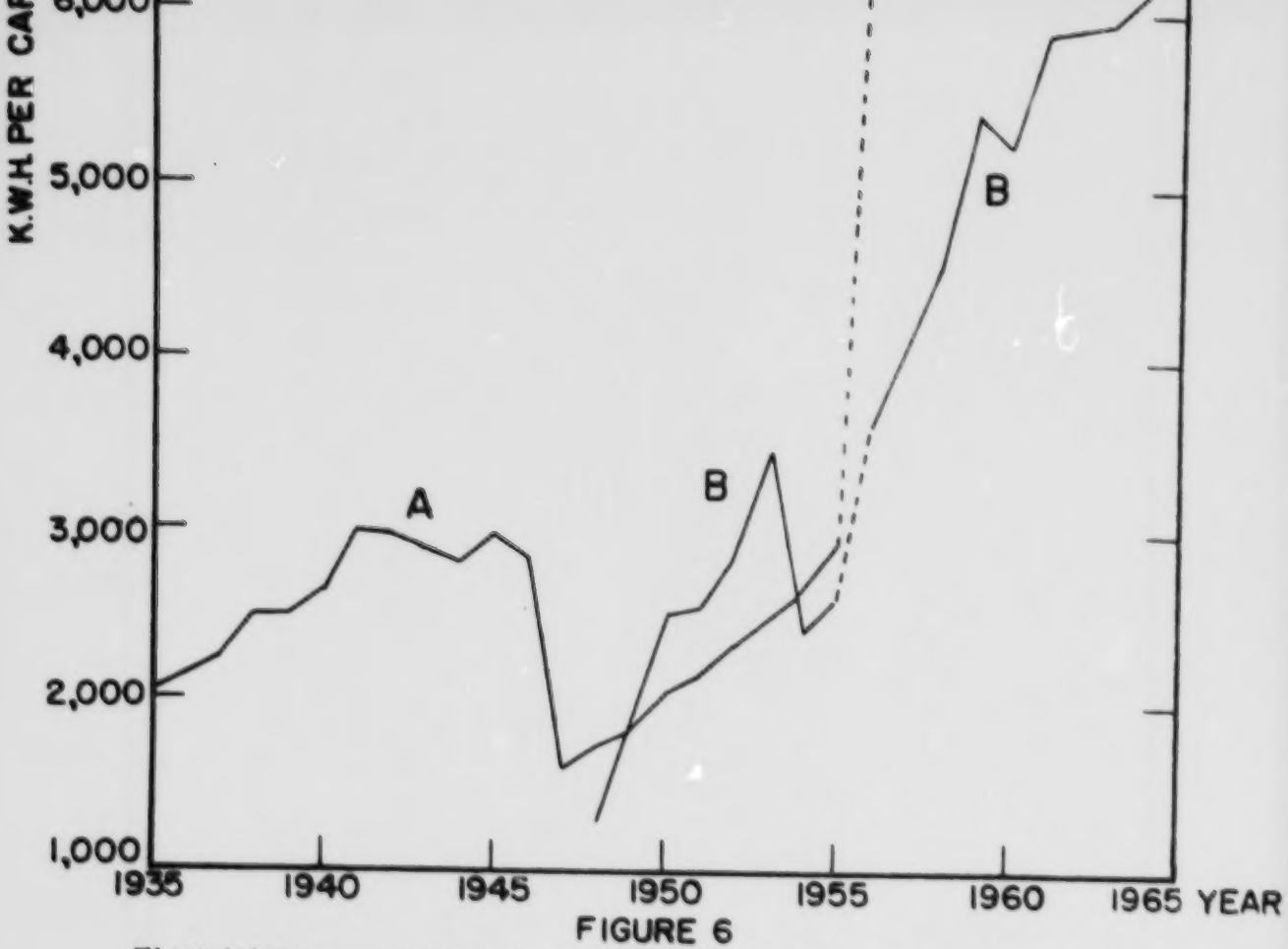


FIGURE 6

Electricity consumption per capita, including industrial establishments after 1956

A. British Columbia.
B. Yukon and Northwest Territories.
Source: D.B.S.

Comparable data for Newfoundland are available only since 1950, as shown in Figure 7. Although the electricity consumption per capita is much lower than the national average, its rate of increase is among the highest.

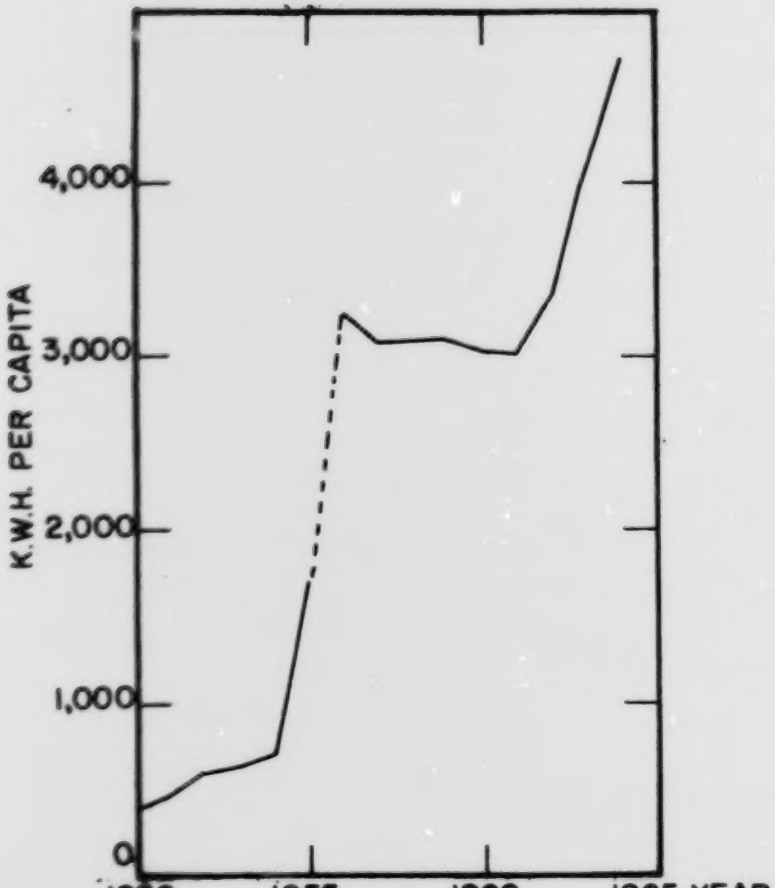


FIGURE 7

Newfoundland electricity consumption per capita, including industrial establishments after 1956.

Source: D.B.S.

TRENDS IN THE PER CAPITA CONSUMPTION OF ENERGY FROM THE VARIOUS SOURCES IN CANADA

Electricity is only one of the forms of energy consumed in Canada. Although most of this electrical energy - about 80 per cent in 1965 according to Table 1 - was obtained from hydro-electric plants, the remaining 20 per cent was produced from various fossil fuels[1] in the approximate proportions of 70 per cent for coal, 10 per cent for oil and 20 per cent for natural gas.

TABLE 1

CANADA
GENERATION - 1965
(THOUSANDS OF KILOWATT-HOURS)

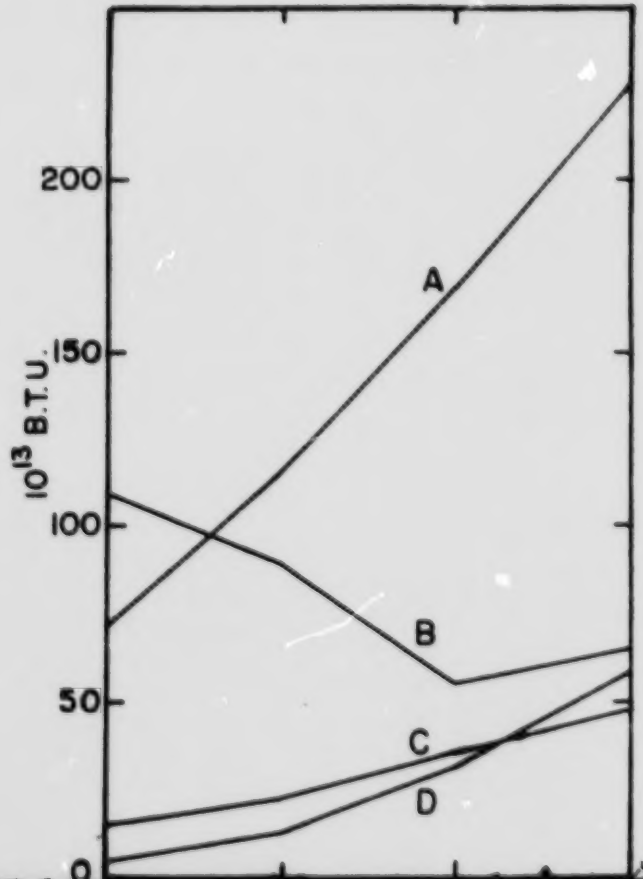
Electric Utility and Industrial Establishments:		
		%
Hydro	117,063,328	81.1
Thermal	27,090,363	18.8
Nuclear	120,139	0.1
	144,273,830	100.0

Electric Utilities:			**Industrial Establishments:**	
		%		%
Hydro	87,648,416	79.1	29,414,912	87.9
Thermal	23,029,064	20.8	4,061,299	12.1
Nuclear	120,139	0.1	-	-
	110,797,619	100.0	33,476,211	100.0

By Fuel in Electric Utilities:		
		%
Coal	15,689,067	67.8
Oil	2,575,936	11.1
Gas	4,758,781	20.6
Nuclear and Other	125,419	0.5
	23,149,203	100.0

Source: D.B.S.

However these fuels supply much more energy directly without conversion into electricity, as shown in Figure 8, which gives the trends in energy consumption in Canada from 1950 to 1965, at five year intervals, for the main sources of energy, each one valued according to its calorific content, in 10^{13} British Thermal Units (Btu). Petroleum and Natural gas sources have provided the fastest regularly increasing amounts of energy, while hydro-electric supplies have increased at a much slower rate. After a sharp decrease in the 1950's, coal and coke supplies are making a slow come-back in the 1960's.



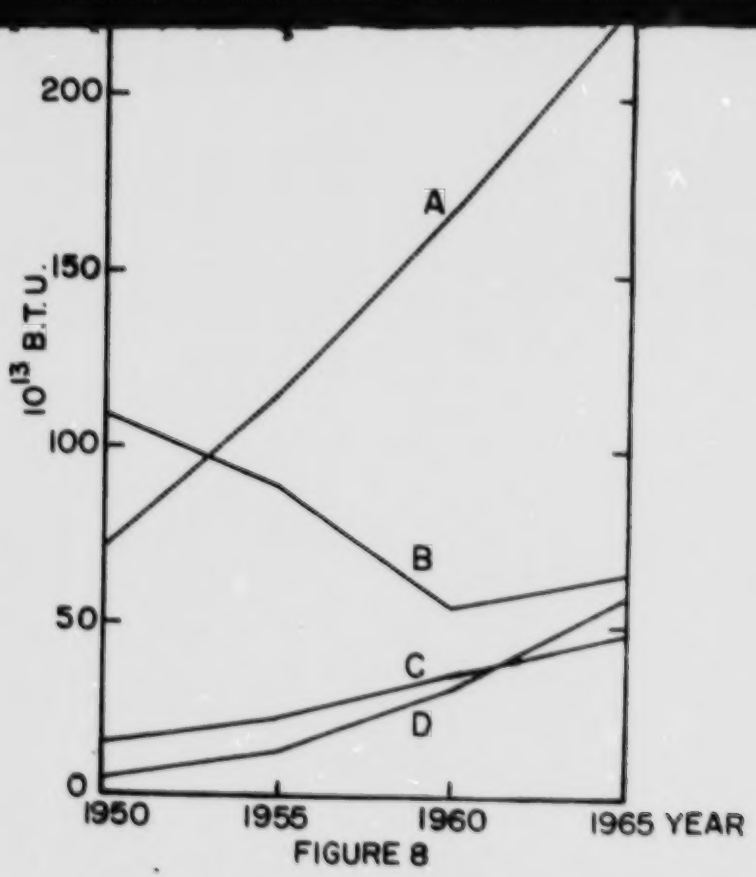


FIGURE 8

Energy consumption based on calorific content.

Energy source:

A. Petroleum
B. Coal and Coke
C. Hydro-electricity
(Estimated at 3400 Btu/ kwh)
D. Natural Gas
(Estimated at 1000 Btu/ cft)

Source: National Energy Board (N. E. B.) for Petroleum and Coal and Coke.
D. B. S. for Gas and Hydro-electricity

In order to compare the various sources of energy, the data of Figure 8 have been converted into percentages in each of the 4 years 1950, 1955, 1960 and 1965, as shown in Figure 9. The proportions of the various sources of energy after wide fluctuations in the 1950's seem to be stabilised in the 1960's about the following rates: sixty per cent for petroleum after a notable expansion from 35 per cent in 1950, fifteen per cent for coal and coke as well as for natural gas, and ten per cent for hydro-electricity, which has remained most stable, whereas coal and coke dropped from 50 per cent in 1950, when gas was recorded at only 2 per cent.

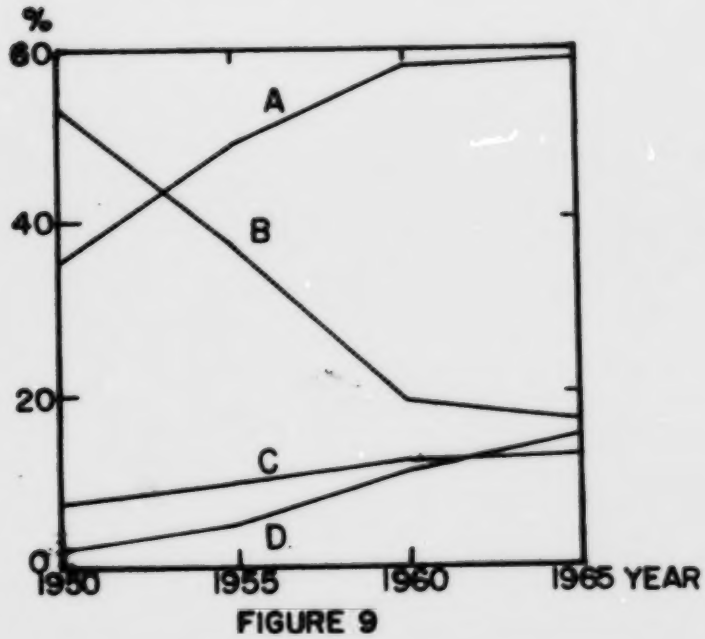


FIGURE 9

Proportions of energy sources in the Btu consumption (based on Figure 8)

Energy Source: A. Petroleum
B. Coal and Coke
C. Hydro-electricity
D. Natural Gas.

Source: N.E.B. and D.B.S.

Because of the large and changing population increase in Canada, the data of Figure 8 have been computed on a per capita basis, as shown in Figure 10, which gives a better illustration of the decline of coal and coke supplies in the 1950's and of the recent stability of hydro-electricity individual consumption. The corresponding population data are given in Table 2.

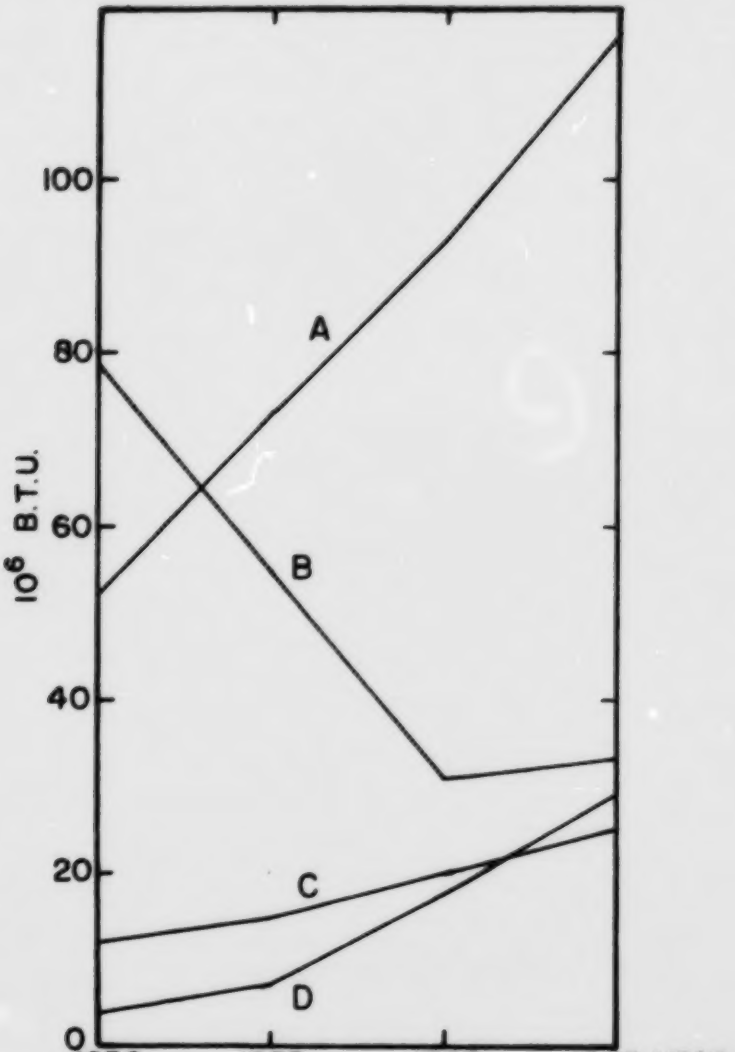


FIGURE 10

Btu energy consumption per capita

Energy source: A. Petroleum
B. Coal and Coke
C. Hydro-electricity
D. Natural Gas.

Source: N.E.B. and D.B.S.

All the data considered so far make possible comparisons of the main energy sources on the basis of their calorific contents for fossil fuels and calorific equivalent for hydro-electricity. This is the usual conventional presentation of such data, but it tends to show natural gas and, even to a higher degree, hydro-electricity as far less important than they really are, as sources of energy, because of the large differences in conversion efficiencies of calorific contents into usable energy for the various energy sources[2], as shown in Table 3, giving estimated assumptions of average conversion efficiencies in Canada.

TABLE 2

POPULATION OF CANADA

Year	Millions of Persons
1950	13.7
1955	15.8
1960	18.0
1965	19.6

Source: D.B.S.

TABLE 3

Energy Source	Estimated average conversion efficiency from calorific content to usable energy	
	Percentage	Assumed number of btu required per kwh of power yielded
Hydro-electricity	90%	4,000 btu/kwh
Natural gas	70%	5,000 "
Petroleum	35%	10,000 "
Coal and Coke	45%	8,000 "

Obviously the actual figures on the basis of these assumptions are much more open to argument than the calorific contents generally used, because conversion efficiencies vary so much from one application to another. Although the data based on calorific contents or equivalent are fairly accurate, they may lead to fallacious conclusions for comparisons of energy sources, and it is therefore preferable to compute approximate data, closer to the physical reality of usable energy based on assumed conversion efficiencies, rather than more accurate data showing contained rather than usable energy.

Figure 11 shows the same data as Figure 8, but after conversion into usable energy consumptions based on the efficiency rates given in Table 3, in billions (10^9) of kwh.

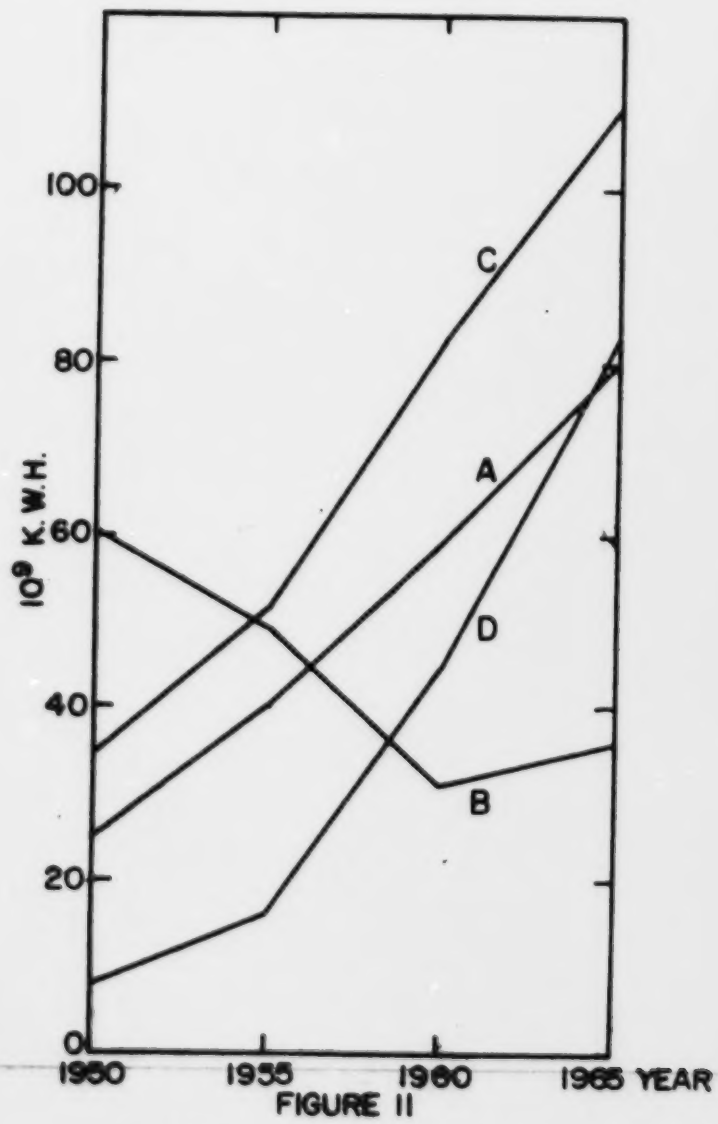


FIGURE 11

Usable energy consumption based on assumed efficiences.

Energy Sources: A. Petroleum
B. Coal and Coke
C. Hydro-electricity
D. Natural Gas.

Source: D.B.S.

The same data are given in percentage form in Figure 12. These data show in a more direct manner the relative importance of hydro-electricity, accounting for about 35 per cent of all energy supplied instead of 12% on a calorific basis, coal and coke being only slightly reduced from 16% to 12% in its share as a source of energy. On the other hand, petroleum furnished about 25% instead of nearly 60% on a calorific content basis, whereas natural gas provided about 27% instead of 15% on a calorific content basis.

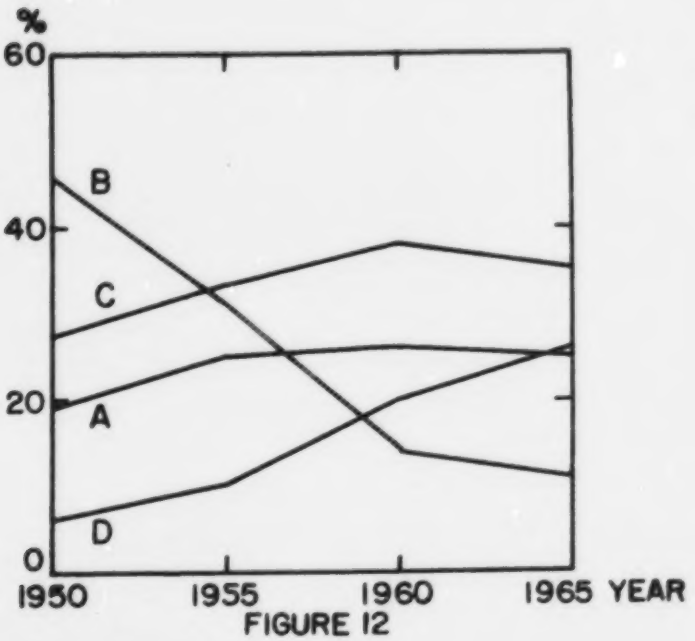


FIGURE 12

Proportion of the energy sources in the usable energy kwh consumption.
(based on Figure 11)

Energy Source: A. Petroleum
B. Coal and Coke
C. Hydro-electricity
D. Natural Gas.

In order to take into account the large population increases in Canada from 1950 to 1965, the data of Figure 11 have been adjusted on a per capita basis, as shown in Figure 13, in thousands of kwh.

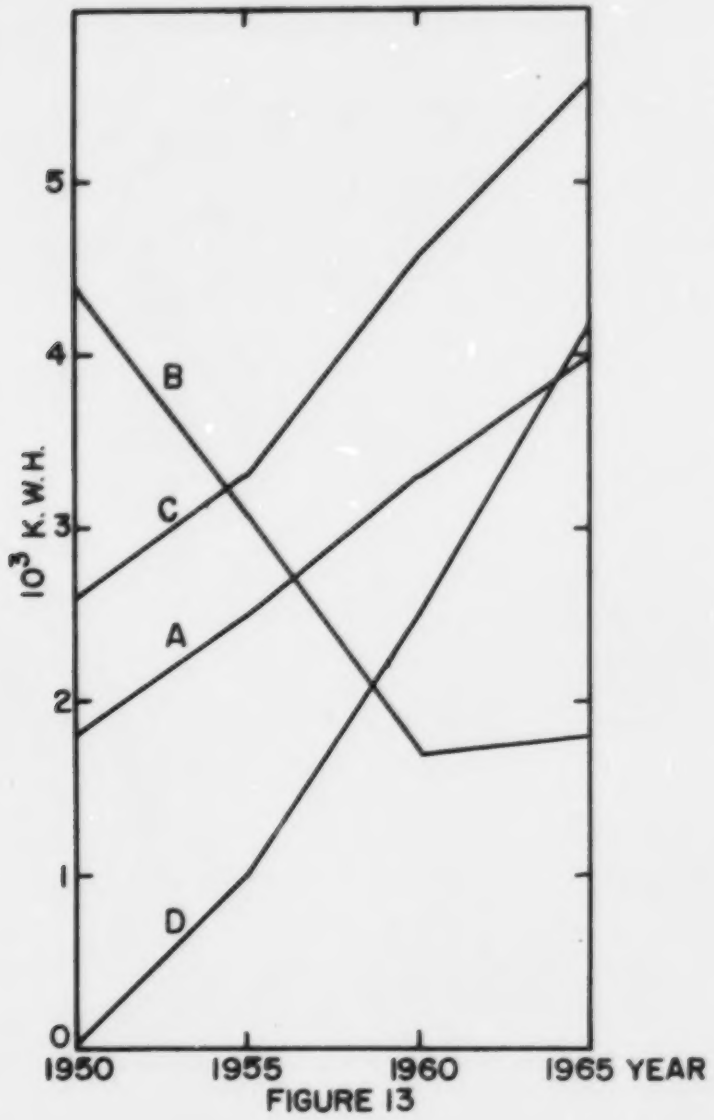


FIGURE 13

Usable energy consumption per capita based on assumed efficiencies.

Energy source: A. Petroleum
B. Coal and Coke
C. Hydro-electricity
D. Natural Gas.

Finally, Figure 14 shows the average annual per capita percentage increase or decrease of usable energy consumption over each five year period between 1950 and 1965 for the main sources of energy in Canada.

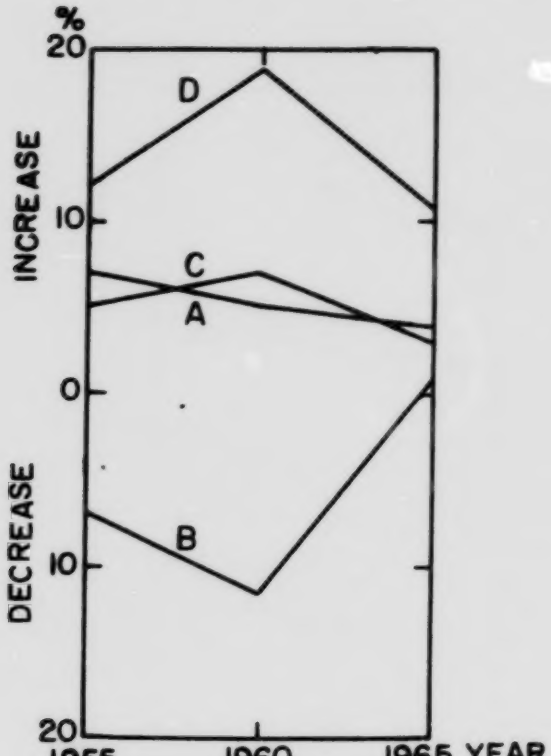


FIGURE 14

Average annual per capita increase or decrease of usable kwh energy consumption during previous five year period.

Energy source: A. Petroleum
B. Coal and Coke
C. Hydro-electricity
D. Natural Gas.

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(2) Vissac, G.A., Charbonnier, R.P. Comparison of Canadian Energy Prospects. Engineering Journal of the Engineering Institute of Canada, April 1964.